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SUM FREQUENCY GENERATION OF DUAL-WAVELENGTH Nd:YAP LASER IN $LiIO_3$ CRYSTAL

by

Zhou Yuping, Shen Hongyuan, et al.

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SUM FREQUENCY GENERATION OF DUAL-WAVELENGTH Nd:YAP LASER IN $LiIO_3$ CRYSTAL

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Abstract: Based on Sellmeier's equations for $LiIO_3$ crystal, the phase-matched condition for sum-frequency generation of 1.0795 μm and 1.3414 μm dual wavelength Nd:YAP laser has been calculated. The calculated results agree well with the experimental ones. The CW and pulsed 0.5981 μm sum-frequency radiation have been achieved for the first time.

Key words: $LiIO_3$ sum frequency, Nd:YAP dual wavelength laser

The multiwavelength laser is a useful light source of nonlinear frequency conversion. In references [1, 2], KDP and KDP crystals are used to obtain pulsed sum frequency radiation with wavelength at 0.589 and 0.582micrometer in dual-wavelength Nd:YAG and Nd:YLF laser devices. In this article, data of refractive index in reference [3] are used to derive Sellmeier equation of $LiIO_3$ crystal for calculating 1.0795 and 1.3414 micrometer radiation with the corresponding match conditions of sum frequency in this type of crystals. Based on the calculation results, for the first time the pulsed and continuous 0.5981 micrometer sum frequency radiation was obtained in $LiIO_3$ crystal by using 1.0795 micrometer and 1.3414 micrometer dual-wavelength Nd:YAP laser.

I. Analysis

$LiIO_3$ crystal is of category No. 6; in optics, the crystal is a negative monoaxial crystal. As indicated in calculation, the effective nonlinear coefficient is zero for this category of crystals during phase matching. In the situation of category I phase matching, the sum frequency process of three wave interaction satisfies

$$\vec{K}^{e}_{3\omega}=\vec{K}^{0}_{1\omega}+\vec{K}^{0}_{2\omega} \qquad (1)$$

or

$$n^{e}_{3\omega}(\theta_m)=\frac{\lambda_3}{\lambda_1}n^{0}_{1\omega}+\frac{\lambda_3}{\lambda_2}n^{0}_{2\omega} \qquad (2)$$

After simple calculation, the phase matching angle and the effective nonlinear coefficient are, respectively,

$$\sin^2(\theta_m)=\frac{(n^{e}_{3\omega})^2\left\{\left[\frac{n^{0}_{3\omega}}{\frac{\lambda_3}{\lambda_1}n^{0}_{1\omega}+\frac{\lambda_3}{\lambda_2}n^{0}_{2\omega}}\right]^2-1\right\}}{(n^{0}_{3\omega})^2-(n^{e}_{3\omega})^2}, \qquad (3)$$

and

$$d_{eff}=d_{31}\sin\theta_{m0} \qquad (4)$$

By using data of refractive index in reference [3], with least square method fitting, then we derive the Sellmeter equation of $LiIO_3$ crystal as the following.

$$n_0^2=3.4142+\frac{4.6877\times10^{-2}}{\lambda^2-3.7378\times10^{-2}}-7.6766\times10^{-3}\lambda^2, \qquad (5)$$

$$n_e^2=2.9161+\frac{3.6650\times10^{-2}}{\lambda^2-2.1170\times10^{-2}}-2.3194\times10^{-3}\lambda^2. \qquad (6)$$

Table 1 lists values of refractive index of different wavelengths by using equations (5) and (6) for calculation. The table also lists the measurement values of reference [3] for comparison. From the table, it is shown that calculated and measured values match quite well. From the refractive index values in Table 1 and equa5tions (3) and (4), we obtain the following:

$$\theta_m=26.42^\circ,\ d_{eff}=\ 5.824\ \text{e. s. u.}$$

Table 1 The refractive indices of $LiIO_3$ crystal at different wavelengths

Wavelengths (nm)	n_o		n_e	
	Cal. values	Exp. values	Cal. values	Exp. values
1367.4	1.8508	1.8508	1.7122	1.7122
1341.4	1.8512		1.7125	
1079.5	1.8566		1.7162	
1014.0	1.8584	1.8584	1.7176	1.7176
598.1	1.8862		1.7390	
589.6	1.8875	1.8875	1.7400	1.7400
579.1	1.8892	1.8894	1.7413	1.7413
546.1	1.8952	1.8953	1.7458	1.7457
508.6	1.9037	1.9037	1.7521	1.7521

II. Experiments and Results

Fig. 1 shows the experimental setup. By using the 1.0795-micrometer and 1.3414-micrometer dual-wavelength continuous and pulsed Nd:YAP laser devices [4] developed by the authors, the output 1.0795-micrometer and 1.3414-micrometer laser as two fundamental-wave radiations. Passing through a lens with a focal length of 8.5cm, the laser light is focused onto an $LiIO_3$ crystal. The included angle between normal line of the crystal plane and z axis is 26.4^0; the crystal is 15mm long along the light passing direction. Let c axis of the b-axis Nd:YAP crystal to be parallel to z axis of $LiIO_3$ crystal because both the 1.0795-micrometer and 1.3414-micrometer laser lights of the b-axis Nd:YAP crystal are parallel to the linear polarized light [5, 6] along the polarized direction. Thus, with placement of two types of crystals, the 1.0795-micrometer and 1.3414-micrometer linear polarized laser light outputted from the dual-wavelength Nd:YAP laser device can carry out interaction of category I sum frequency of $o+o \rightarrow e$ in the $LiIO_3$ crystal. For the sum frequency coherent radiation thus obtained, after passing through a spectroscope and a model 44W plane grating monochromator, the radiation is received by a photomultiplier. Then a display is shown on a model ST-22 dual-line oscilloscope for determining the wavelength.

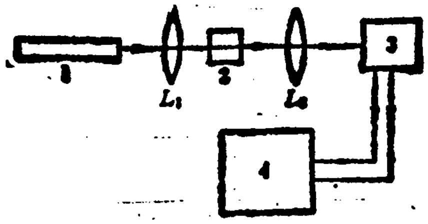

Fig. 1. The experimental set-up for measuring wavelength of radiation of sum frequency mixing
1—Dual wavelength CW or pulsed Nd:YAP laser; 2—$LiIO_3$ crystal; 3—Model 44W grating monochromator; 4—Model ST-22 oscilloscope

Used in the experiment, the dual-wavelength laser has its output power at 1.0795 and 1.3414 micrometer as 5.8 and 5.6 watts, respectively. The dual-wavelength pulsed laser operates in free state; the output energies are 0.5 and 0.3 joule, respectively. Under operating state of continuous and pulsed laser, orange-color coherence radiation can be obtained from $LiIO_3$ crystal. Between the position of the maximum measured value of orange-color coherence radiation thus measured, and the normal line of crystal plane, the deviation is less than 0.5^0. By using model 44W plane grating monochromator, the measured wavelength of orange-color light is 0.5981 ± 0.0002 micrometer.

By using the Nd^{3+} ion with the $^4F_{3/2}-^4I_{11/2}$ and $^4F_{3/2}-^4I_{13/2}$ jump, a dual-wavelength laser is generated. With its sum frequency function, continuous orange-color coherence radiation is obtained. Notwithstanding at present, only milliwatt level orange-color coherence radiation is generated. However, by raising power density of fundamental wave in nonlinear crystal, and by using other nonlinear crystals with larger nonlinear coefficient, the output power will be increased.

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REFERENCES

1 C. G. Bethea, *IEEE J. Quant. Electr.*, **QE-9**, 254 (1973)

2 W. Volmar, M. G. Knights *et al.*, Conference on Laser and Electro-Optics, Digest of Technical Papers, **188** (1983)

3 S. Umegaki., S. I. Tanaka *et al.*, *Opt. Commun.*, **3**, 244 (1971)

4 H. Y. Shen, R. R. Zeng *et al.*, *Appl Phys. Lett.*, **56**(20), 1937 (1990)

5. Shen Hongping and Zhou Yuping et al, WULI XUEBAO [PHYSICS], 31(9), 1235 (1982).

6 Shen Hongyuan *et al.*, *SCIENTIA SINICA* (*SCIECE IN CHINA*), Series **A**, **29** (11), 1224 (1986)

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